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(71) Applicants
The Post Office, 23
Howland Street, London
W1P 6HQ
(72) Inventor
Paul Christopher Hensel
(74) Agent
Roger George Miselbach

(54) Joining optical fibres

(57) In a machine for preparing and aligning two glass optical fibres for joining, the fibres 4, 4a are clamped in approximate alignment by clamps 3, 3a, and each fibre is bent out of line and severed in a manner that will give suitable end surfaces for joining (for example, by scribing with a tungsten carbide or diamond blade 9, 9a). On

breaking the fibres spring back into alignment and are now ready for joining *in situ*, after fine adjustment if necessary. A joining jig 13 can now be slid into position and the joint made. The machine is preferably adapted to accommodate a number of interchangeable joining jigs of different types, for example, tape wrapping jig (Fig. 5, not shown) and an adhesive jig (Figs. 6 and 7, not shown).

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

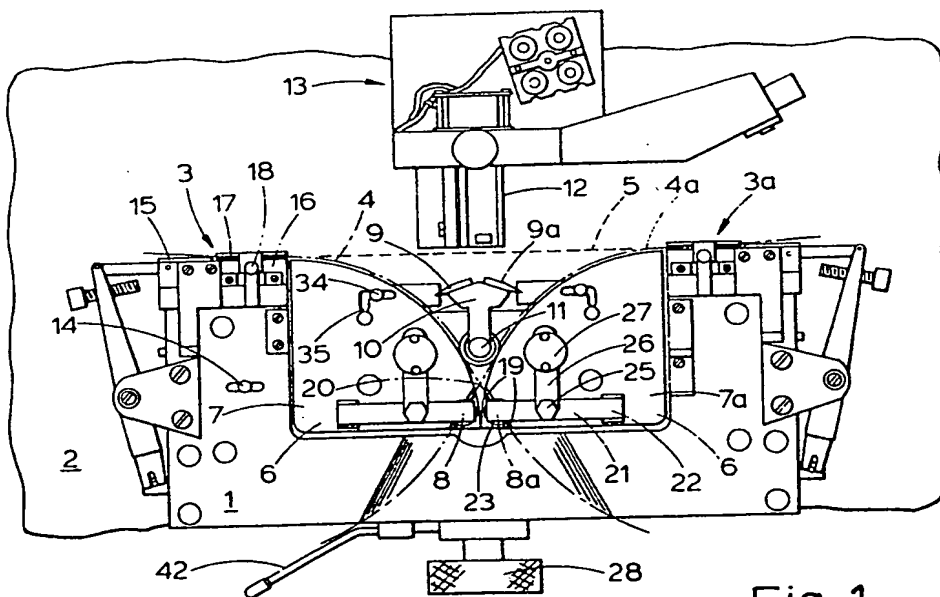


Fig. 1

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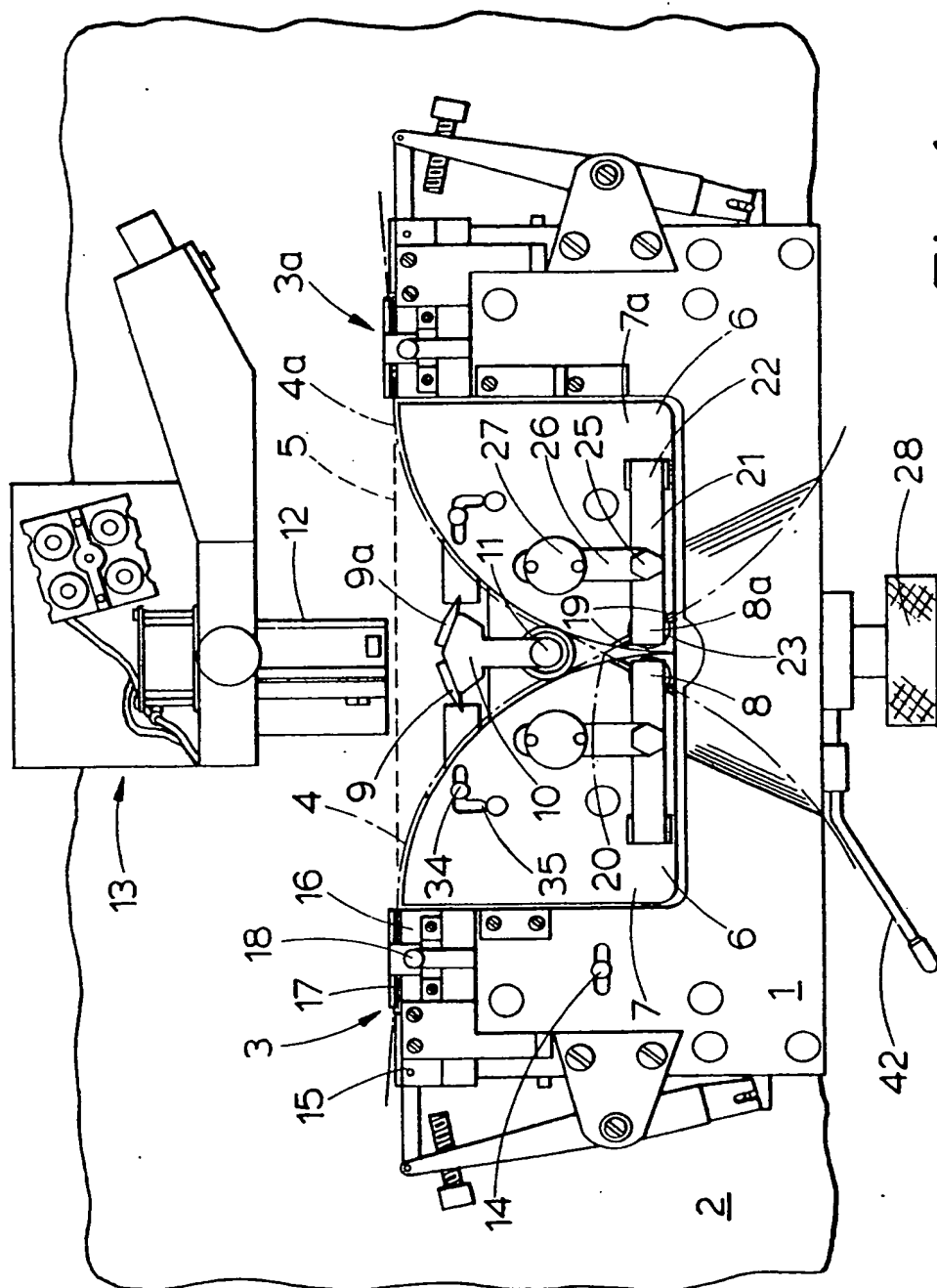


Fig. 1.

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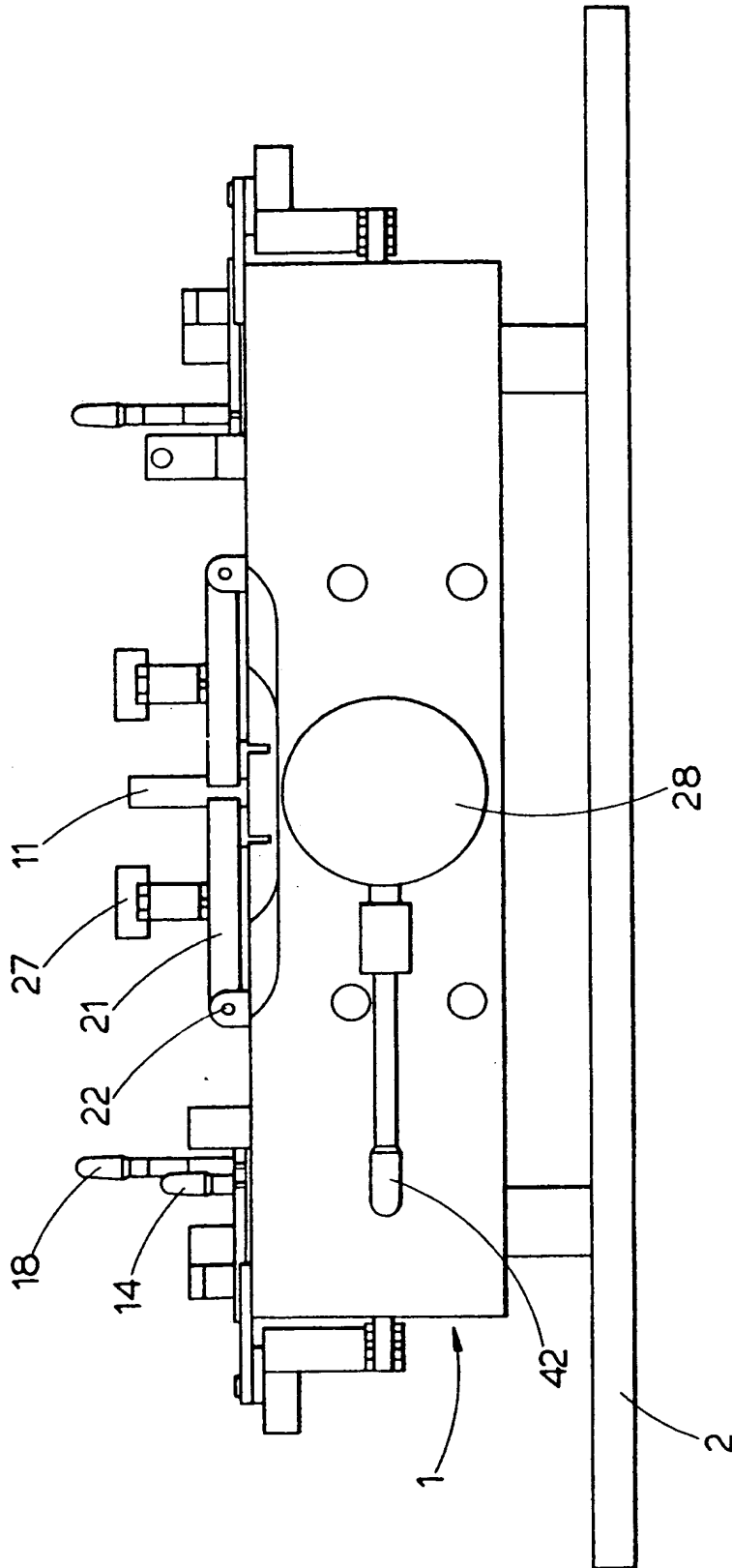


Fig. 2

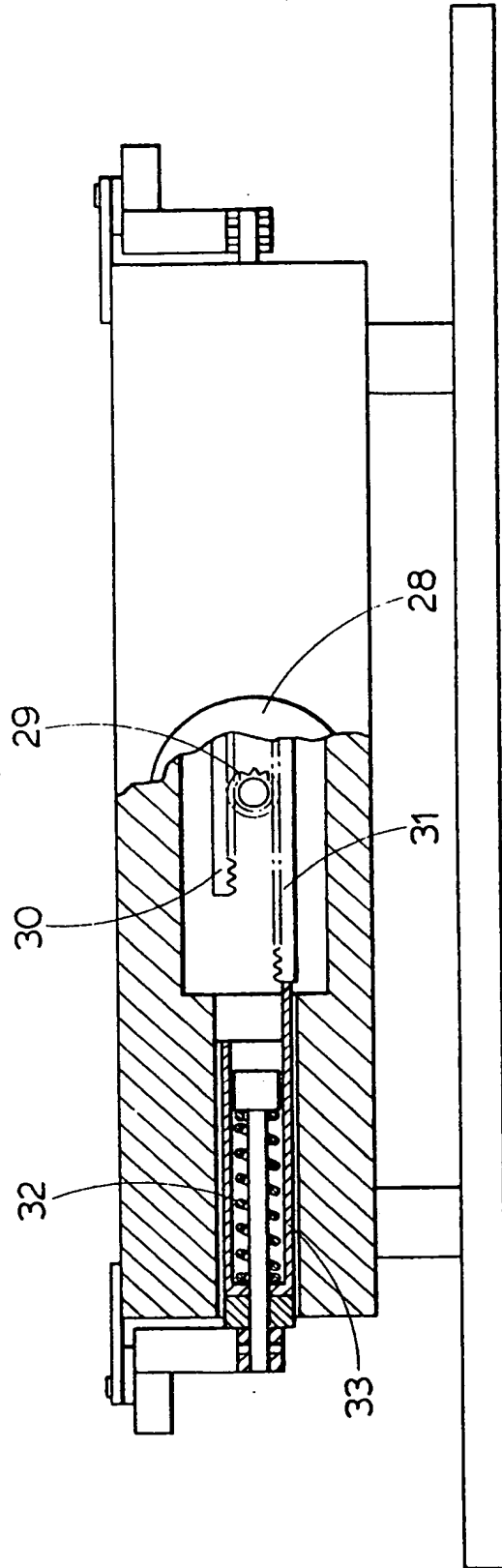


Fig. 2a

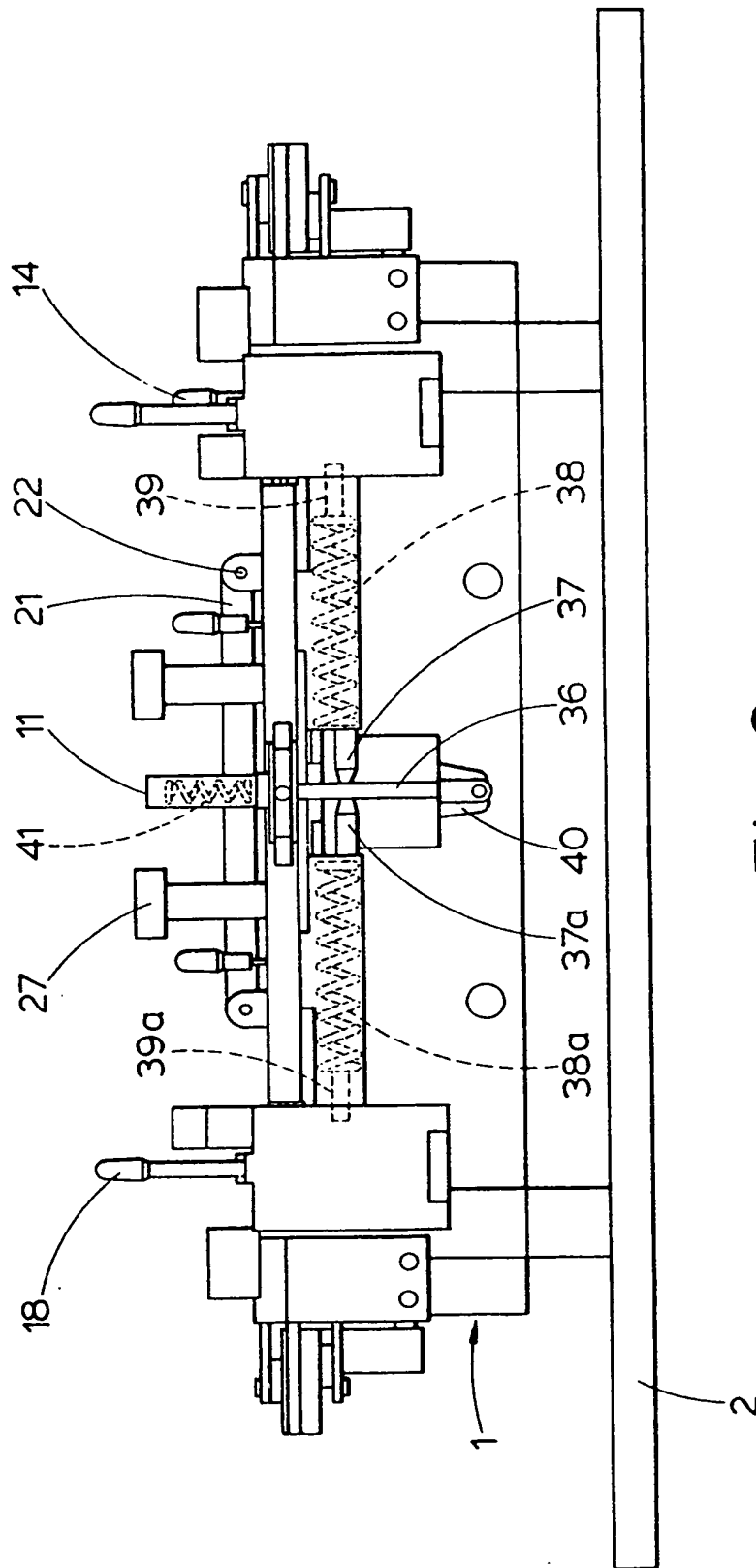


Fig. 3

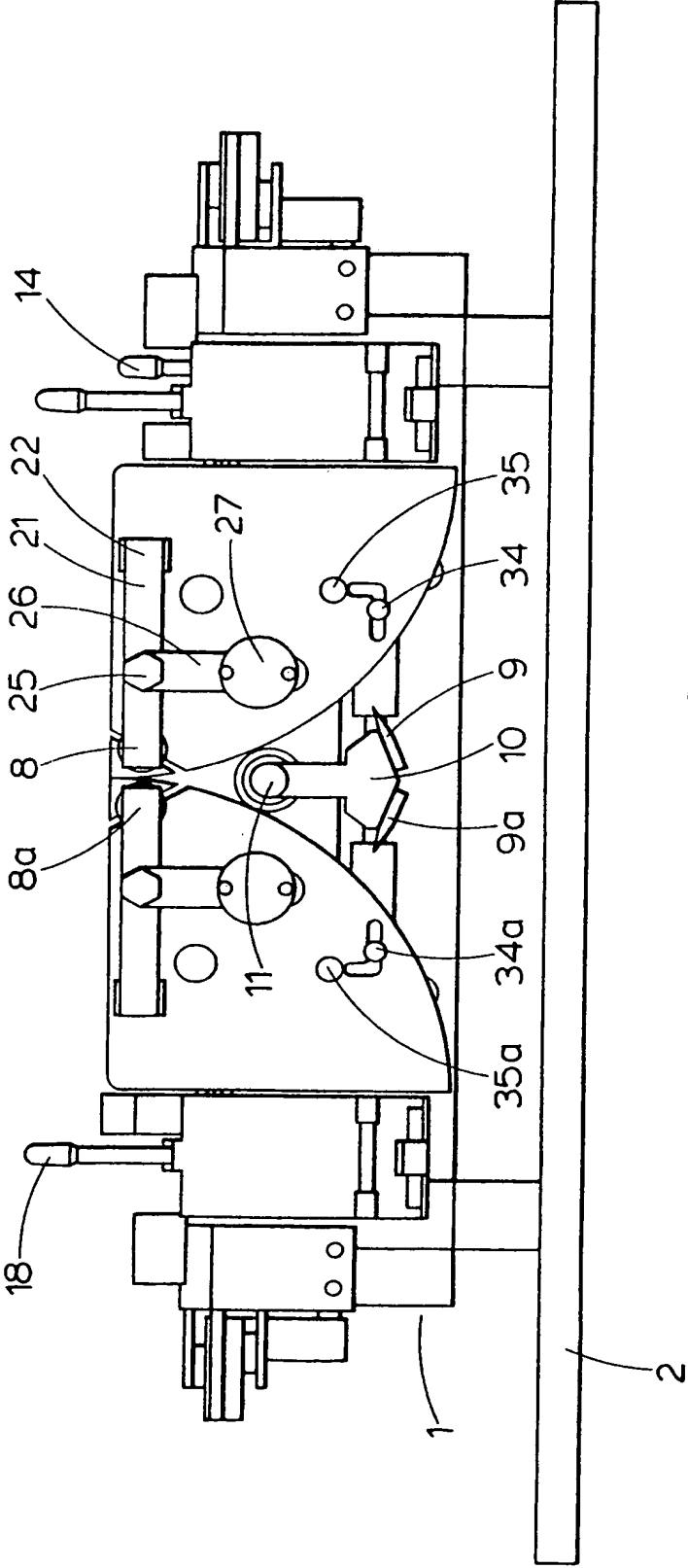


Fig. 3a

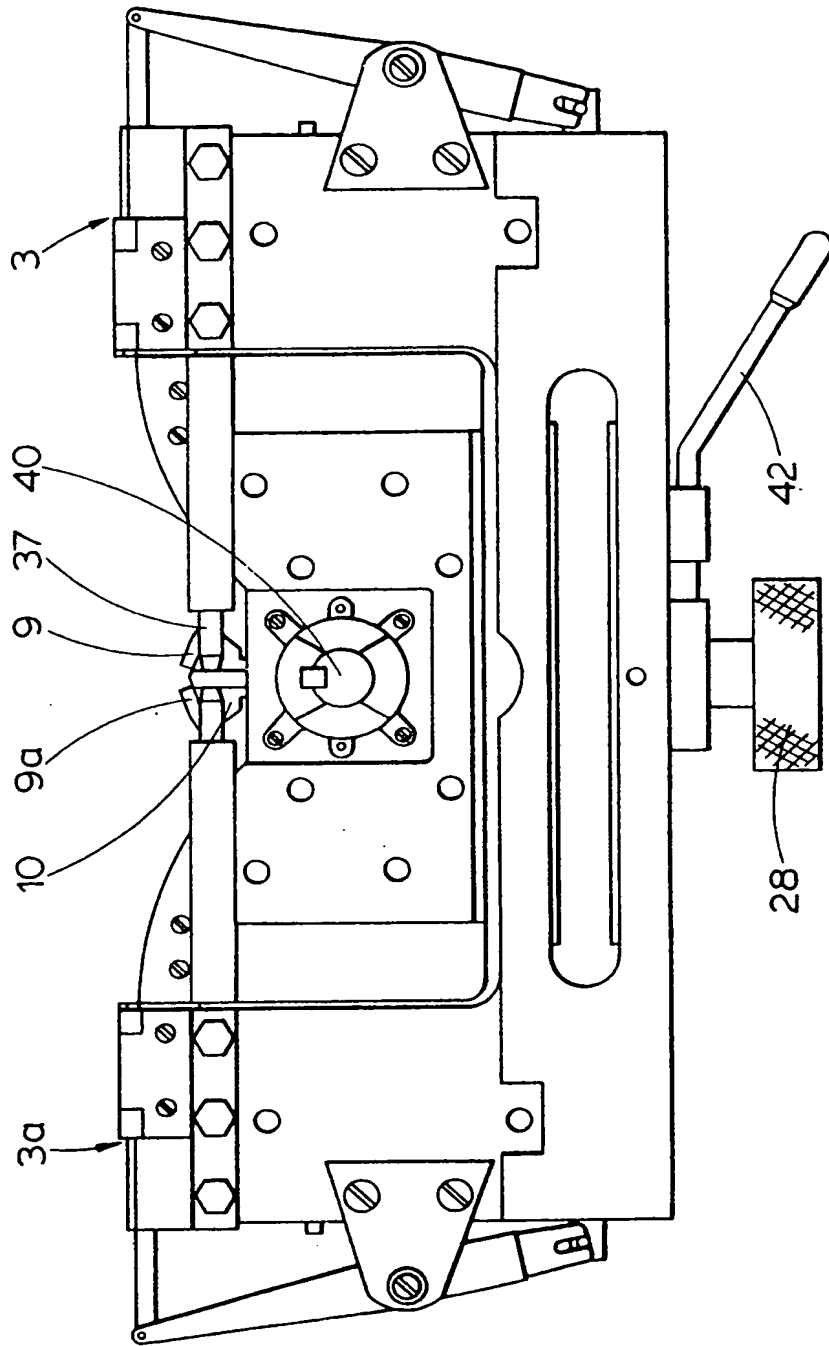


Fig. 4

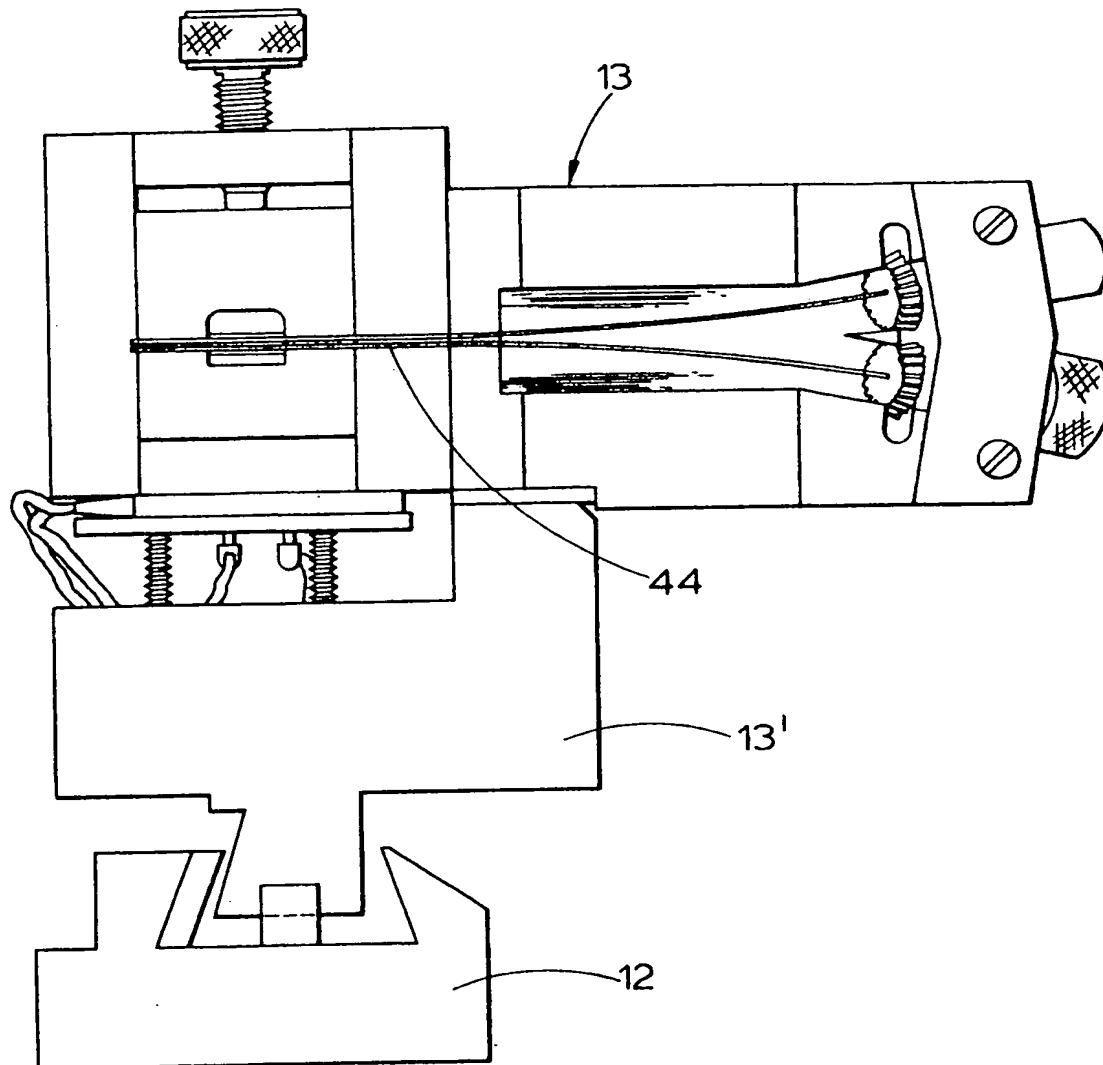


Fig. 5

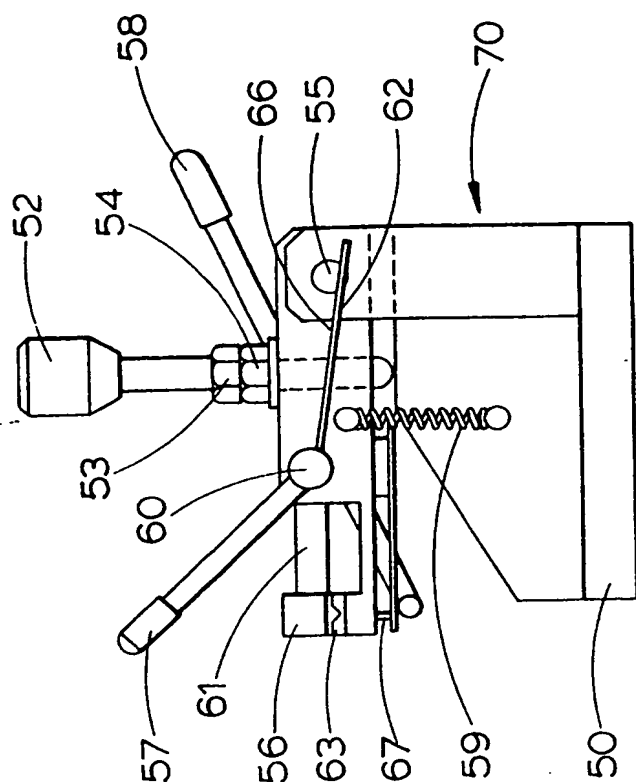


Fig. 7

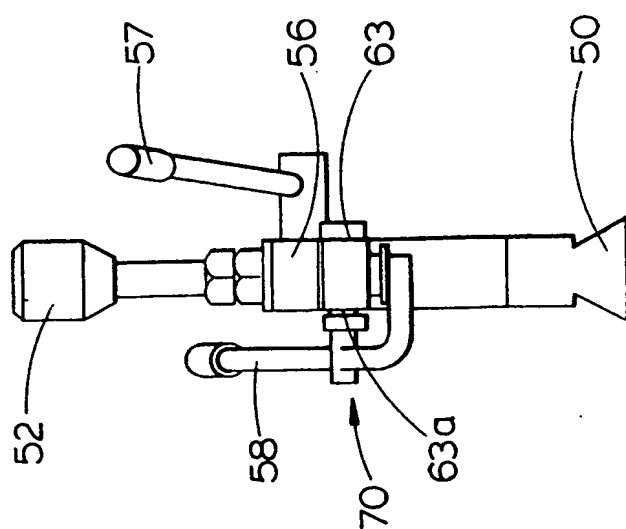


Fig. 6

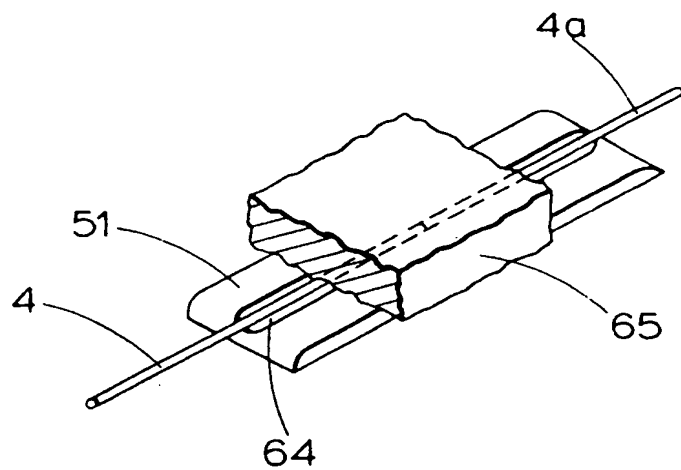


Fig. 8

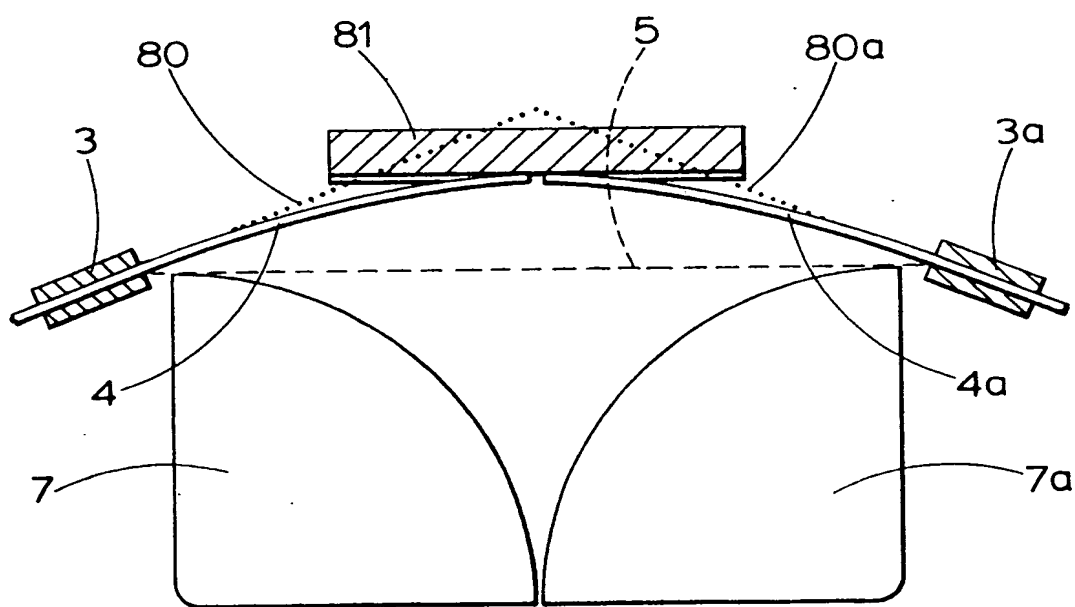


Fig. 9

SPECIFICATION

Improvements in or relating to the breaking and jointing of optical fibres

The present invention relates to apparatus and
 5 a method for preparing and aligning the ends of optical fibres for subsequent jointing. Using the apparatus and method of the invention, two optical fibres may be prepared for jointing by breaking to give suitable ends, and at the same
 10 time suitably aligned, so that the ends may subsequently be joined together without removing the fibres from the apparatus, using an integral or associated jointing device.

According to the present invention there is
 15 provided apparatus for preparing and aligning two glass optical fibres for jointing, which apparatus comprises:

(a) means, including first and second spaced-apart clamping devices, adapted to hold two
 20 optical fibres in alignment with one another,

(b) means arranged to divert out of alignment that region of each fibre thus held that lies between the first and second clamping devices, and

(c) means for initiating or creating a break in each fibre in the diverted region at a point so chosen that, after breaking, the portions of the fibres held by the clamping devices will spring
 25 back into alignment with one another.

The invention also provides a method for preparing and aligning two glass optical fibres for jointing, comprising the steps of:

(i) clamping first and second optical fibres respectively in first and second spaced-apart
 35 clamping devices,

(ii) diverting that region of each fibre lying between the first and second clamping devices away from the line joining the said devices,

(iii) initiating or creating a break in the diverted
 40 region of each fibre at a point such that, after breaking, the portions of the fibres held by the clamping devices spring back into alignment with one another.

The first and second clamping devices which
 45 hold the fibres throughout the process are conveniently so orientated that the fibres, after breaking, will lie along a straight line joining the clamping devices. When the fibres are to be jointed in a 'v'-groove, however, it may be preferable for
 50 the clamps to be orientated differently. In which case a further element is required to ensure alignment of the fibre ends; this is discussed in more detail below.

After breaking, the fibres revert, as previously
 55 mentioned, to a position of approximate alignment and the apparatus preferably includes means for adjusting the positions of the fibre ends relative to one another prior to jointing. This adjustment may conveniently be effected by making one or both of
 60 the clamping devices moveable, using micrometer control or sufficient gearing for accurate positioning. Alternatively or additionally, means may be provided for locking one fibre in position and adjusting the position of the other using

65 microstages mounted in the vicinity of the relevant clamp.

The means (b) for diverting each fibre out of line for breaking preferably includes a body having a convex curved surface over which the diverted
 70 fibre can be tensioned; such a body will hereinafter be referred to as an anvil. It is well-known that fibre ends of optimum quality can be obtained when the fibre is tensioned in a curve and the break is initiated from the convex side of
 75 the curve; in these circumstances the energy required to effect the break may be just sufficient to give two clean surfaces.

The diverting means thus advantageously includes two curved anvils, one to provide a path
 80 for each fibre, and further clamping devices are provided to secure the fibres at the far end of these curved paths. The original clamping devices or the further clamping devices just mentioned are preferably provided with some mechanism, for
 85 example, springs, for limiting the tension applied to the fibres. Advantageously the tension applied can be varied to suit different fibre types and to facilitate proper adjustment for any particular fibre type.

The means for initiating or creating a break in the fibres, which may for example be a blade of hard material for scratching or 'scribing' the fibres, is provided in the vicinity of the anvils. The blade may for example consist of diamond or tungsten
 90 carbide. In one particularly advantageous arrangement, two blades, one for each fibre, are mounted on a common member moveable between a position in which the first fibre, tensioned around the first anvil, is scribed and a
 95 position in which the second fibre, tensioned around the second anvil, is scribed. The movement is preferably damped so that the blade comes into contact with the fibre in a gentle and controlled manner.

The convex curved surface of each anvil may optionally be provided with a 'v'-groove except in the region of scribing, where the surface is polished; this helps to prevent the fibre from rolling on the anvil as the blade scribes it. Alternatively, at least the fibre-
 100 contacting surface of the anvil may be of resilient material, for example, rubber.

Advantageously, the anvils and associated components are together movable, for example, by tilting, so that after fibre breakage has been
 115 effected these parts can be moved out of the way for the jointing operation. The two anvils are conveniently integral with one another and may form a hinged platform which can be rotated through about 45° from the operating position to provide clearance for jointing. Preferably the
 120 platform may be locked into its operating position.

Advantageously, the apparatus of the invention also includes facilities for jointing the fibres after the ends have been prepared and aligned as
 125 previously described. The apparatus may include an integral or permanently attached jointing device but more conveniently it may be provided with a connecting point, for example, a dove-tail, so that a number of interchangeable jointing jigs

of different types, for example, a tape-wrapping jointer as described in US Patent Specification No 4151030 (corresponding to our co-pending Application No 46609/76), a 'v'-groove jointer and an arc fusion jointer, may be used as desired.

The apparatus and method of the present invention has been found to be especially suited to the technique of 'v'-groove jointing. In this technique, the fibre ends to be jointed are accommodated in a 'v'-shaped groove of appropriate size in a substrate of for example copper or silica, the ends are bonded together using a suitable adhesive, and pressure is applied to the joint from the side opposite the substrate while the adhesive cures. The grooved substrate ensures accurate alignment of the fibres during bonding and afterwards remains part of the finished joint, thus reinforcing it and protecting it against distortion. As previously indicated, it may be advantageous, when using this jointing technique, to orientate the first and second clamping devices slightly away from the anvils so that the fibres, after breaking, will not revert to the straight line between the clamping devices but will go beyond that line, the ends being caught by the 'v'-grooved substrate which is positioned approximately mid-way between the clamping devices on the far side from the anvils. The fibres thus lie with positive force in the 'v'-groove and the substrate acts in concert with the clamping devices to hold the fibres in alignment.

When using the tape-wrapping or fusion methods of jointing, however, the straight-line arrangement is preferred.

One example of apparatus according to the invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a plan view of the apparatus, set up ready for fibre breaking with two fibres inserted;

Fig. 2 is a front elevation of the apparatus of Fig. 1;

Fig. 2a is a partly sectioned view corresponding to Fig. 2;

Fig. 3 is a rear elevation of the apparatus of Fig. 1;

Fig. 3a is a rear elevation corresponding to Fig. 3 but with the apparatus set up for jointing;

Fig. 4 is a view from below of the apparatus of Fig. 1 with the base plate removed;

Fig. 5 is a front elevation of a first jointing jig designed to co-operate with the apparatus of Figs. 1 to 4;

Fig. 6 is an end elevation of a second jointing jig designed to co-operate with the apparatus of Figs. 1 to 4;

Fig. 7 is a side elevation of the jig of Fig. 6;

Fig. 8 shows a detail of a joint made by the jig shown in Figs. 6 and 7; and

Fig. 9 is a schematic plan view of an alternative arrangement of the clamping devices.

Referring generally to Figs. 1 to 4 of the drawings, but especially to Fig. 1, the apparatus has a main frame 1 mounted on a base plate 2.

The main frame 1 carries two spaced-apart clamping devices, generally indicated by the

reference numerals 3 and 3a, each holding an optical fibre, the optical fibres being indicated schematically by chain-dotted lines 4 and 4a respectively. The clamping devices 3 and 3a are aligned, the imaginary line joining them being indicated by dashed line 5. Between the clamping devices 3 and 3a is situated a platform 6 which includes two quadrant-shaped upstanding anvils 7 and 7a providing convex curved surfaces around which the fibres 4 and 4a respectively can be diverted and tensioned. Further clamping devices 8 and 8a hold the diverted fibres 4 and 4a in tension around the anvils 7 and 7a.

Tungsten carbide or diamond blades 9 and 9a are attached to a common bearer 10 pivotally mounted on a shaft 11 positioned symmetrically between the curved anvils 7 and 7a. By rotation of the bearer 10 about the shaft 11 the blade 9 can be brought into contact with the fibre 4, and similarly the blade 9a can be brought into contact with the fibre 4a, to scribe the fibre and initiate a break.

The platform 6 is hinged and may be rotated through about 45 to 60°, such that the edge nearer the clamps 3 and 3a falls and the edge nearer the auxiliary clamps 8 and 8a rises, in order to remove the components associated with the breaking operation from the path 5 prior to jointing. Fig. 3a shows the apparatus with the platform 6 tilted in this way. The platform 6 may be locked in the fibre-breaking position by means of a sliding catch 14.

Mounted on the base plate 2 in the vicinity of the path 5 is a grooved member 12 for accommodating a jointing jig provided with a co-operating dovetail to slide in the groove. In Fig. 1 a tape-wrapping jig indicated generally by the reference numeral 13 is shown. A 'v'-groove jointing jig, described in more detail below, is, however preferred.

Following this general outline of the construction of the apparatus, it will now be described in greater detail with reference to its mode of operation. Since the apparatus is symmetrical, the operation of the left-hand side only will be described except when it is necessary to describe both sides.

In the principal clamping device 3, the optical fibre 4 is passed over guides 15 and 16 and a hinged member 17 raised until it is caught by a lever 18, so that the fibre 4 is clamped between a rubber pad and a smooth metal surface. The fibre 4 is then passed around the curved surface of the upstanding portion 7 of the platform 6 and into a groove 19; it crosses the other fibre 4a at the point 20. An arm 21, one end 22 of which is hinged and the other end of which carries a rubber block 23, is turned downwards so that the rubber block 23 bears on the fibre. Downward pressure is applied to the arm 21 by an adjustable cam 25 carried by an arm 26 and operable by means of a knob 27.

The fibre is now tensioned by means of the principal clamp 3, which is movable as a whole outwardly along the path 5 by turning a large knob

28, mounted on the front of the apparatus, in an anti-clockwise direction. The knob 28 operates via a plunger and rack mechanism and a spring ensures that the fibre is not over-tensioned; this mechanism is shown in Fig. 2a. The knob 28 drives a pinion 29 which moves racks 30 and 31. When the knob 28 is turned anti-clockwise the rack 31 is moved to the right and the clamp 3 moves outwards, thus tensioning the fibre 4; the tension is limited by a spring 32 in the plunger 33. When the knob 28 is turned clockwise the rack 31 is moved to the left and the clamp 3 is moved inwards. Both clamps 3 and 3a are moved simultaneously so that a clockwise movement of the knob 28 causes the clamps to approach one another and vice-versa. The knob 28 may be locked in position by means of a lever 42.

Once the fibre 4 is in position and properly tensioned, the tungsten carbide blade 9 is brought into position by moving a lever 34 towards the outside of the apparatus and latching it into a recess 35. This causes the bearer 10 to pivot around the shaft 11 until the blade 9 rests on the fibre. The bearer 10 has a downward projection 36, best seen in Fig. 3, and on the two sides of this projection are plungers 37 and 37a adjustable by means of screws 39 and 39a respectively. Movement is damped by a dashpot 40. When the lever 34 is moved into the latching recess 35 the plunger 37 is pulled back allowing the pressure exerted by the compression spring 38a to overcome that exerted by the compression spring 38 and to push the bearer 10 via its projection 36 towards the left-hand (from the point of view of Fig. 1) fibre 4. The top of the shaft 11 is then pushed downwards; it moves against an internal spring 41 and causes the blade 9 to scribe the fibre 4. The operation is then repeated to break the fibre 4a, by moving a lever 34a into a latching recess 35a.

When the fibre 4 breaks the portion held by the principal clamp 3 springs back and lies along the path 5. The remaining part of the fibre is released from the auxiliary clamp 8 and discarded. The sliding catch 14 on the platform 6 is released and the platform is rotated as previously described through an angle of from forty-five to sixty degrees.

The large knob 28 is now rotated in a clockwise direction to move the clamps 3 and 3a towards one another so that the freshly severed ends of the fibres 4 and 4a approach one another. Sufficient movement is available to allow the ends to touch.

A jointing jig which is ready mounted in the grooved member 12 is moved up until it is aligned with the fibres; The movement has a positive stop.

In Fig. 5 there is shown a schematic view of a tape-wrapping jointing jig 13 designed to co-operate with the apparatus described above. The jig is described in detail in the Complete Specification accompanying our co-pending Application No. 46609/76, and this view corresponds to Fig. 2 of that Specification. The jig 13 and a base 13' having a dovetail 43 which slides in the grooved member 12 of the main

apparatus.

Figs. 6 and 7 show an alternative jointing jig, indicated generally by the reference numeral 70, which is preferred for use in combination with the apparatus of Figs. 1 to 4, and Fig. 8 shows a joint between two fibres produced using the jig 70. In this jointing method the fibres are aligned and bonded on a copper or silica substrate 51 (Fig. 8) having a 'v'-groove of dimensions matched to the fibres; the substrate remains part of the finished joint.

The 'v'-grooved substrate 51 is first inserted below the aligned fibres 4 and 4a to be joined. To make this insertion, the whole upper part of the jig 70 tilts downwards through about 45°; the joint is then returned to the horizontal position by turning a knob 52 and locked at the correct height by means of locknuts 53 and 54. Reference numeral 59 represents a tension spring.

Initially, a lever 57 is moved towards the knob 52 thus raising a silica pressure block 56 which is mounted on an arm 61 pivoted about a shaft 60 shared with the lever 57. When the knob 52 is turned to raise the jig to the horizontal position, the fibres 4 and 4a are guided by guides 63 and 63a respectively into the groove 64 in the substrate 51. A small quantity of suitable adhesive is placed in the groove 64 between the ends of the fibres 4 and 4a. The adhesive preferably has a refractive index matched to that of the fibres and may, for example, be an epoxy resin such as Araldite (Trade Mark) AV100/HV100, a UV-curable resin such as Loctite (Trade Mark) 357, or a cyanoacrylate.

After application of the adhesive, a thin piece of silica or other transparent material 65 is placed on top and the pressure block 56 lowered by moving the lever 57 in the forward direction away from the knob 52. The fibre ends are then brought into abutment by turning the large knob 28 on the front of the main apparatus. During this operation it is useful to increase the pressure applied to the joint by latching a wire spring 66 on to a projection 62 protruding from the shaft 55. The adhesive is then cured by the application of ultra violet light (in the case of a UV-curable resin) or heat (in the case of an epoxy resin). When the adhesive is cured, the spring 66 is released, the lever 57 is turned and the joint is exposed. It may be lifted from the jig 70 by means of ejector pins 67 carried on a leaf spring 68 operated by a lever 58. The substrate 51 remains a part of the finished joint.

The use of a 'v'-grooved substrate allows highly accurate alignment of the fibres prior to and during bonding and the finished joint is reinforced and protected from bending by the presence of the substrate.

Fig. 9 is a very schematic plan view showing an alternative arrangement of the clamps 3 and 3a suitable for a slightly different method of 'v'-groove jointing. In this arrangement the clamps 3 and 3a are slightly angled so that after breaking the fibres 4 and 4a will tend to revert not to the straight line path 5 but to positions 80 and 80a

respectively beyond it. A 'v'-grooved substrate 81 is so positioned as to catch the fibre ends in the 'v'-groove and thus to confine the fibres to a curved path between the positions 80, 80a and the line 5. The force generated in the fibres by bending them tends to hold them in the 'v'-groove, where they can be bonded together. This arrangement has the advantage of requiring less accurate adjustability of the clamps 3 and 3a.

It will be appreciated that in Fig. 9 the sizes of the fibres 4 and 4a, the 'v'-groove and the angles between the lines 80, 80a and the line 5 have all been greatly exaggerated for the sake of clarity.

CLAIMS

1. Apparatus for preparing and aligning two glass optical fibres for jointing, which apparatus comprises:—

(a) means, including first and second spaced-apart clamping devices, adapted to hold two optical fibres in alignment with one another,

(b) means arranged to divert out of alignment that region of each fibre thus held that lies between the first and second clamping devices, and,

(c) means for initiating or creating a break in each fibre in the diverted region at a point so chosen that, after breaking, the portions of the fibres held by the clamping devices will spring back into alignment with one another.

2. Apparatus as claimed in claim 1, which includes means for precisely positioning the fibre ends with respect to one another after breaking.

3. Apparatus as claimed in claim 1 or claim 2, wherein the diverting means (b) includes an anvil having a convex curved surface over which a fibre held by the first or second clamping device can be tensioned.

4. Apparatus as claimed in claim 3, wherein the diverting means (b) includes two said anvils, one to provide a curved path for each fibre, and further clamping devices for securing the fibres at the ends of the curved paths remote from the first and second clamping devices.

5. Devices as claimed in claim 4, wherein the first and second clamping devices or the further clamping devices are provided with means for limiting the tension that can be applied to fibres tensioned over the anvils.

6. Apparatus as claimed in any one of claims 1 to 5, wherein the means (c) includes at least one blade of hard material for scribing the surface of a fibre to initiate a break.

7. Apparatus as claimed in claim 6, wherein the means (c) comprises two blades, one for each fibre, mounted on a common member moveable between a position for scribing a fibre tensioned around the first anvil and a position for scribing a fibre tensioned around the second anvil.

8. Apparatus as claimed in claim 7, wherein the means (c) also includes means for damping the

movement of the common member so as to control the approach of each blade towards its respective anvil.

9. Apparatus as claimed in any one of claims 1 to 8, wherein the anvils are moveable away from their operating positions subsequent to the fibre breaking operation so as to provide increased clearance for jointing.

10. Apparatus as claimed in claim 9, wherein the anvils together form a hinged platform that can be rotated around a horizontal axis away from the operating position.

11. Apparatus as claimed in any one of claims 1 to 10, wherein the apparatus includes a connecting point for attaching means for jointing together, subsequent to the breaking operation, two aligned fibres held respectively by the first and second clamping devices.

12. Apparatus as claimed in any one of claims 1 to 10, which further includes means for jointing together two aligned optical fibres held respectively by the first and second clamping devices.

13. Apparatus for preparing and aligning two glass optical fibres for jointing, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

14. A method for preparing and aligning two glass optical fibres for jointing, which method comprises the steps of:

(i) clamping first and second optical fibres respectively in first and second spaced-apart clamping devices,

(ii) diverting that region of each fibre lying between the first and second clamping devices away from the line joining the said devices,

(iii) initiating or creating a break in the diverted region of each fibre at a point such that, after breaking, the portions of the fibres held by the clamping devices spring back into alignment with one another.

15. A method as claimed in claim 14, carried out using apparatus as claimed in any one of claims one to 13.

16. A method for jointing together two optical fibres, wherein the fibres are prepared and aligned by a method as claimed in claim 14 or claim 15 and the freshly severed ends of the two fibres held by the first and second clamping devices are subsequently jointed together.

17. A method as claimed in claim 16, wherein the fibre ends are jointed together by bonding with adhesive while located in a 'v'-grooved substrate.

18. A method for preparing and aligning two glass optical fibres for jointing, carried out substantially as hereinbefore described with reference to the accompanying drawings.

19. A method for jointing together two glass optical fibres, carried out substantially as hereinbefore described with reference to the accompanying drawings.